ATMOSPHERIC FORCING AND ITS SPATIAL VARIABILITY OVER THE JAPAN SEA

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LONG-TERM GOALS

The long-term goal of this study is to improve our understanding of the marine atmospheric boundary layer (MABL), its spatial structure and variability, and the resultant ocean surface forcing over the Japan/East Sea (JES).

OBJECTIVES

The main objectives are (1) to determine the structure and variability of the MABL over the JES on synoptic and seasonal time scales, (2) to estimate surface wind stress and heat flux time series during summer and winter conditions, and (3) to examine the role of the coastal mountain ranges along the western perimeter of the JES on the low-level air flow and surface forcing during winter, with special emphasis on cold-air outbreak events.

APPROACH

This study is part of the ONR Japan/East Sea Directed Research Initiative to examine frontal processes, circulation, and water property evolution in the Japan/East Sea during 1999–2000. Our

approach is (1) to make ship and fixed-point meteorological measurements on selected JES cruises to investigate MABL structure and surface forcing variability during summer (1999) and winter (2000) conditions, (2) to collect and analyze JMA buoy weather data, regional WMO surface and upper-air data, sta-tionary weather satellite imagery, and ECMWF surface fields to determine the synoptic setting during our *in-situ* measurement periods, and (3) to conduct a process-oriented model study to gain dynamical understanding of the wintertime orographically modified flow, and to compare these model flows to observations and to results from more complex models.

WORK COMPLETED

Meteorological data were collected on two *R/V Revelle* cruises in the JES this spring–summer. C. Dorman (SDSU) participated on the May 19 – June 3 SeaSoar cruise conducted by C. Lee (U. Washington, Chief Scientist) to study the polar front. Dorman mounted additional meteorological sensors at several levels to complement the ship's IMET suite of measurements and improve the vertical sampling in the MABL up to 23 m. Atmospheric soundings were also made on this cruise to obtain vertical profiles of temperature, humidity, pressure and winds. A free balloon was used to carry a Vaisala, GPS sonde once a day to above 300 hPa (10 km). The surface observations will be used as a context for the soundings to characterize the lower atmosphere. IMET data were also collected on the June 22 – July 15 hydrographic cruise conducted by L. Talley (SIO, Chief Scientist) to map water property distributions in Korean and Japanese territorial waters. The IMET sensors returned useable data on both cruises with the exception of short- and long-wave radiation. The causes of these failures are being investigated.

A set of self-contained ASIMET instruments and GPS recorder were built at WHOI and tested before being mounted on the R/V *Professor Khromov* in mid-July by R. Limeburner (WHOI) with help from A. Sherebinin and I. Filippov, Far Eastern Regional Hydromet Research Institute (FERHRI), Vladivostok. These instruments were deployed to obtain high-quality measurements of wind speed and direction, barometric pressure, relative humidity, air temperature, sea surface temperature, short- and long-wave radiation, precipitation, and ship's position during the July 22 – August 12 hydrographic cruise organized by Talley to map water property distributions in Russian territorial waters. The ASIMET and GPS units were left on the ship during the August 27 – September 28 hydrographic cruise conducted by Talley (Chief Scientist) in the Sea of Okhotsk. Figure 1 shows the combined cruise tracks taken from the WHOI GPS data. The WHOI meteorological instruments were recovered when the ship stopped in Otaru, Japan. All instruments returned usable data, although the air temperature sensor failed during the Sea of Okhotsk cruise. Initial data processing has begun and the instruments are being refurbished in preparation for deployment on the *Khromov* in Feburary 2000.

One hypothesis of this study is that the sea level gap at Vladivostok in the Sikhote-Alin mountain range along the western perimeter of the JES strongly controls the structure of the MABL and surface forcing during winter cold-air outbreaks. Dorman has deployed an automated weather station at Vladivostok to monitor conditions there, and has begun collecting Russian weather data in collaboration with S. Varlamov (FERHRI), who plan to prepare a climatology of winter cold-air events. As a first step towards investigating the dynamics of the orographically-modified air flow through the Vladivostok gap, A. Roderson (WHOI) completed a description and user's guide for a nonlinear shallow-water numerical model to study flow over topography. This model has been transferred to A. Scotti (U. North Carolina), who will assume Rogerson's role in this study.

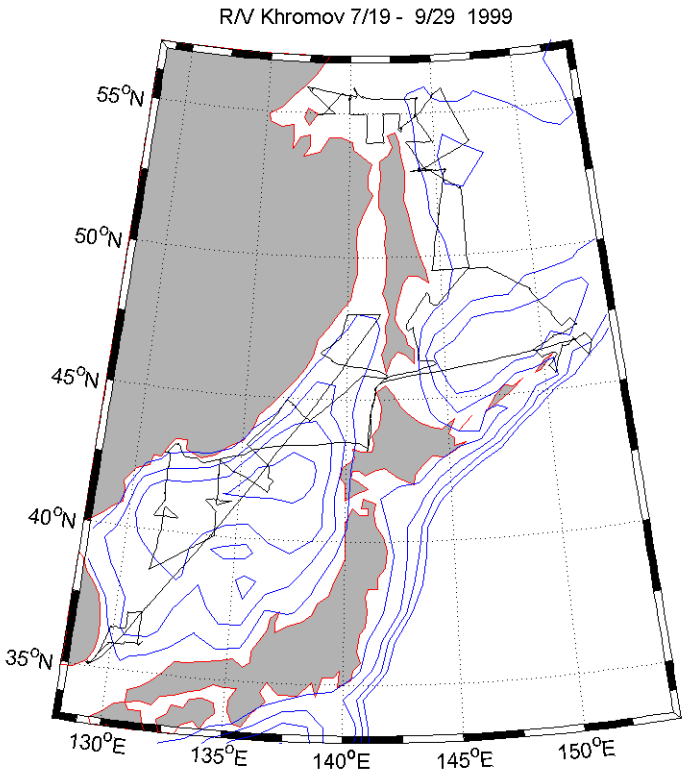

Figure 1. The cruise track of the R/V Professor Khromov during the summer 1999 hydrographic cruises to the Sea of Japan and Sea of Okhotsk.

RESULTS

There were considerable changes of the atmospheric structure in the lower 300 m as measured by *R/V Revelle* balloon soundings during the May 19 – June 3 cruise. The air–sea temperature difference was both positive and negative. As the sea temperature differs from the near surface air temperature by only a few degrees, the difference readily changes sign when the wind direction and low-level air mass changes. An example of the marine boundary layer structure with a colder sea surface and a surface based inversion occurred on May 23 when the marine air was capped by a low inversion with a strength of 7°C. The winds in the lower 3 km were a maximum and from the south at sea level. In contrast, on May 24, the sea surface temperature was warmer than the air and the air temperature inversion base shifted to 300 m capped by an overcast stratus layer. The ships's surface station time series for the day revealed a slightly warmer sea surface with increasing wind speeds, rain and falling pressure marking the passage of a weak disturbance over the JES. After the center of the cyclone passed, the weak inversion was replaced with humid, less stable air while the sea surface was only slightly warmer than the air.

IMPACT / APPLICATIONS

None.

TRANSITIONS

None.

RELATED PROJECTS

This study is part of the ONR Japan/East Sea DRI. The atmospheric measurements, compiled observational and model products, and the idealized model results will be relevant to many of the other projects in the DRI. We plan to combine our ship and fixed-point measurements with winter aircraft observations to be made by C. Friehe (UC-Irvine), drifter wind and pressure measurements being collected by P. Niller (SIO), and other data to describe specific cold-air outbreak events and associated surface forcing fields. S. Chen (U. Miami) plans to use our *in-situ* atmospheric observations in her 3-D meso-scale model assimilation and validation work. Results from our idealized shallow-water modeling will be compared with her model simulations, with emphasis on understanding the dynamics of the orographically modified flow.

PUBLICATIONS

Rogerson, A. M., 1999. A Shallow-Water Model for Hydraulically Transcritical Flows. WHOI Technical Report, **WHOI-99-09**, 59 pp.